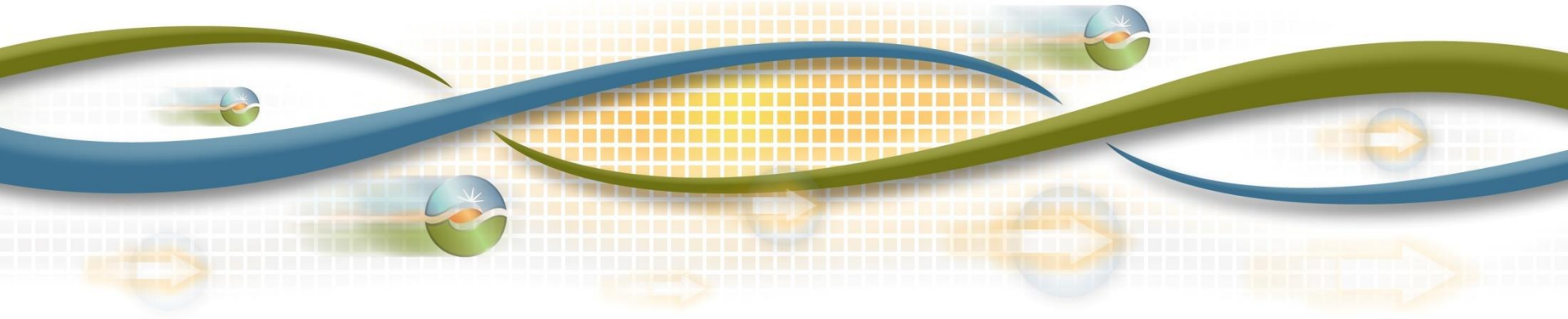


# CEC Forecasting Workshop

## Panel 2

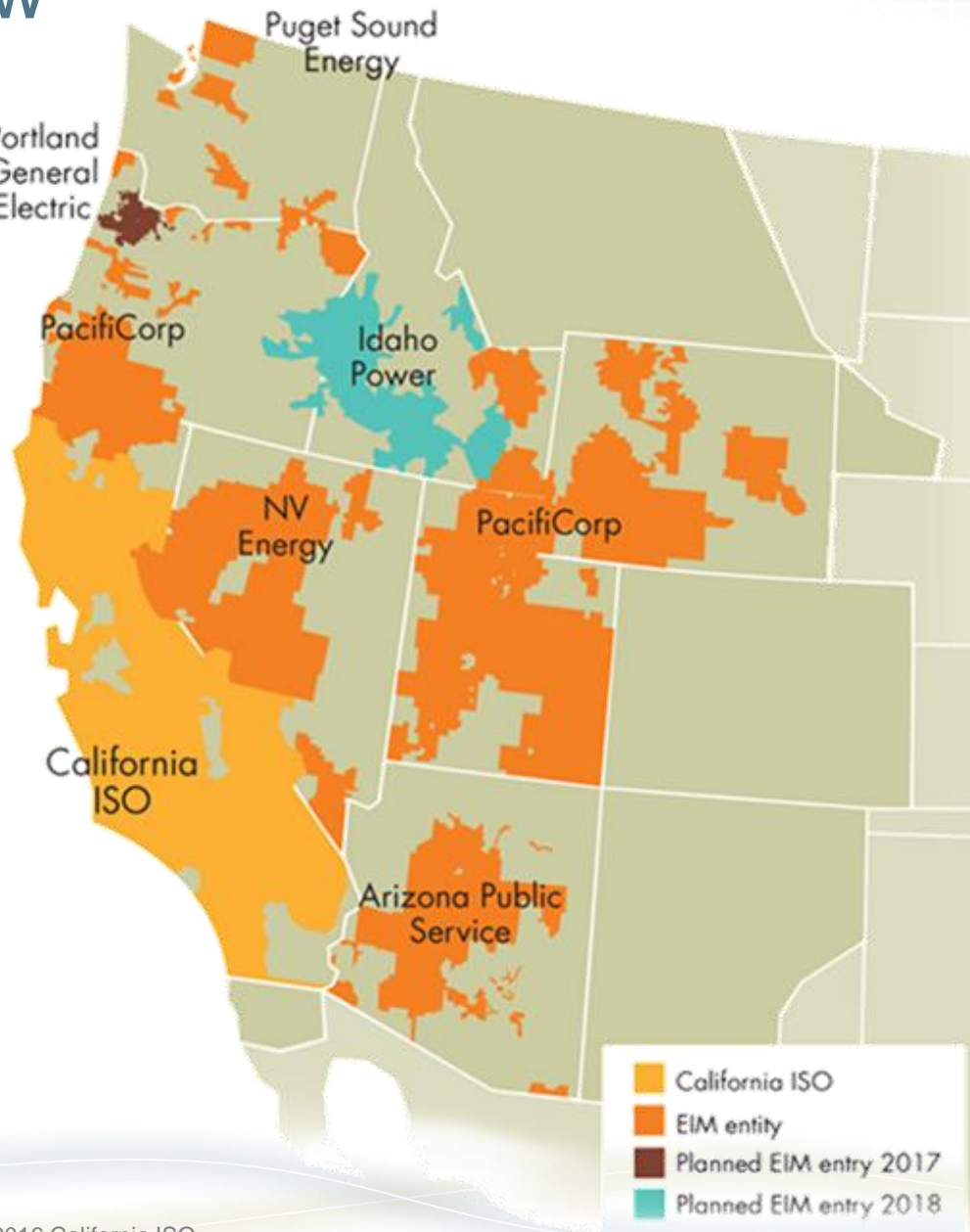
### Forecasting Gaps, Building a Sensor Network, and Managing Costs

Amber Motley; Manager, Short Term Forecasting  
January 17<sup>th</sup>, 2017



# California ISO Overview

- Nonprofit public benefit corporation
- Part of Western Electricity Coordinating Council: 14 states, British Columbia, Alberta and parts of Mexico
- 71,000 MW of power plant capacity
- 50,270 MW record peak demand (July 24, 2006)
- 26,014 circuit-miles of transmission lines
- ISO is governed by the Federal Energy Regulatory Commission, which has jurisdiction over transmission lines that cross state borders.



# Power industry transformation



## Wind

- 4768 MW Peak – April 12, 2014
- 6087 MW Installed Capacity



## Solar Thermal / Photo Voltaic

- 8,545 MW Peak – September 14, 2016\*
- 8,843 MW Installed Capacity

\*April 24, 2016 simultaneous wind and solar exceeded 10,000MW



## Roof Top Solar

- Behind the meter – Residential
- 4,600 MW Estimated Capacity

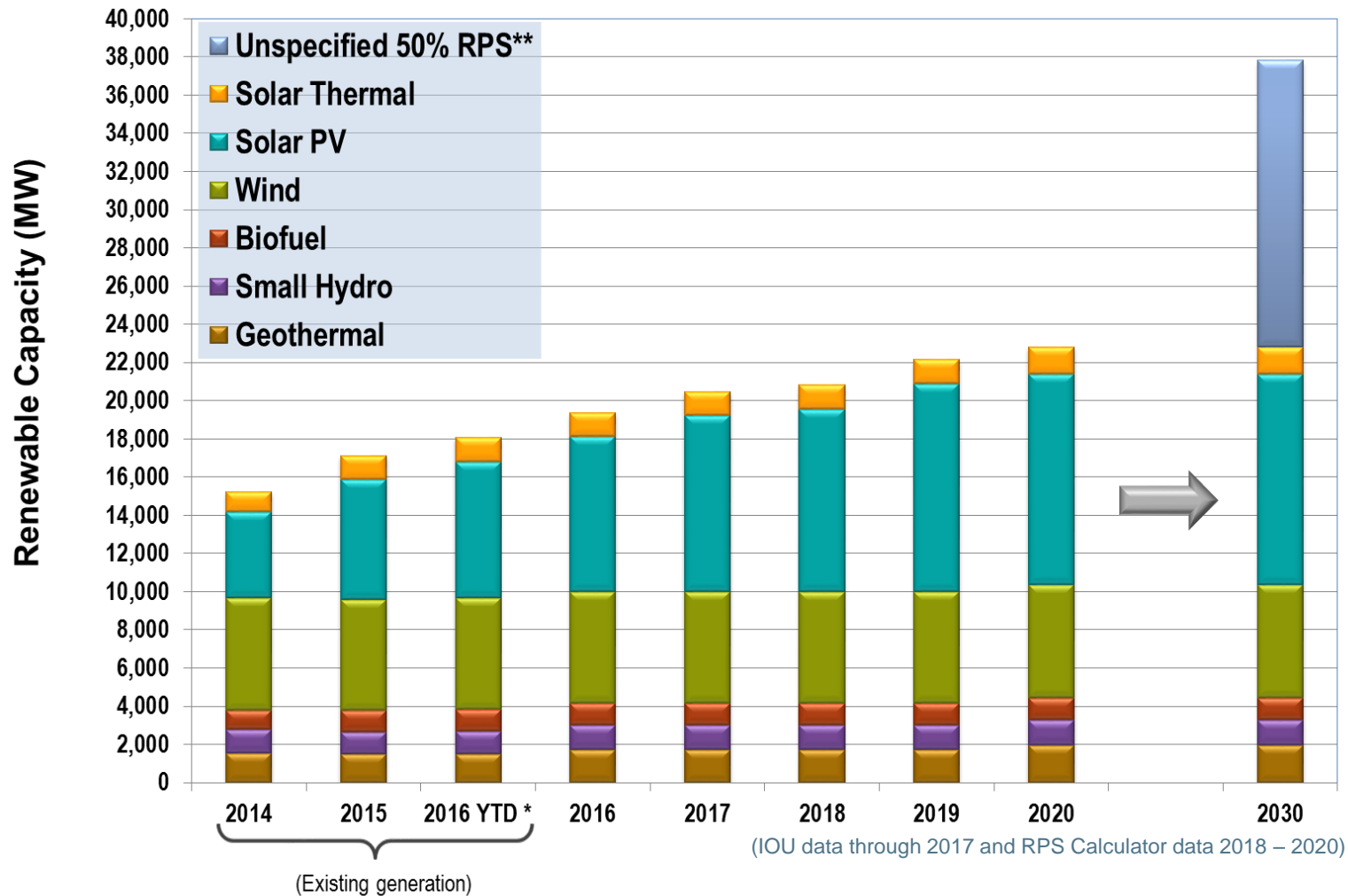
## Main Drivers:

- ✓ California RPS
- ✓ GHG reduction
- ✓ Once-through-Cooled plants retirement

## Goals:

- ✓ Higher expectation of reliability
- ✓ Higher expectation of security
- ✓ Smart Grid
- ✓ Situational awareness through Visualization

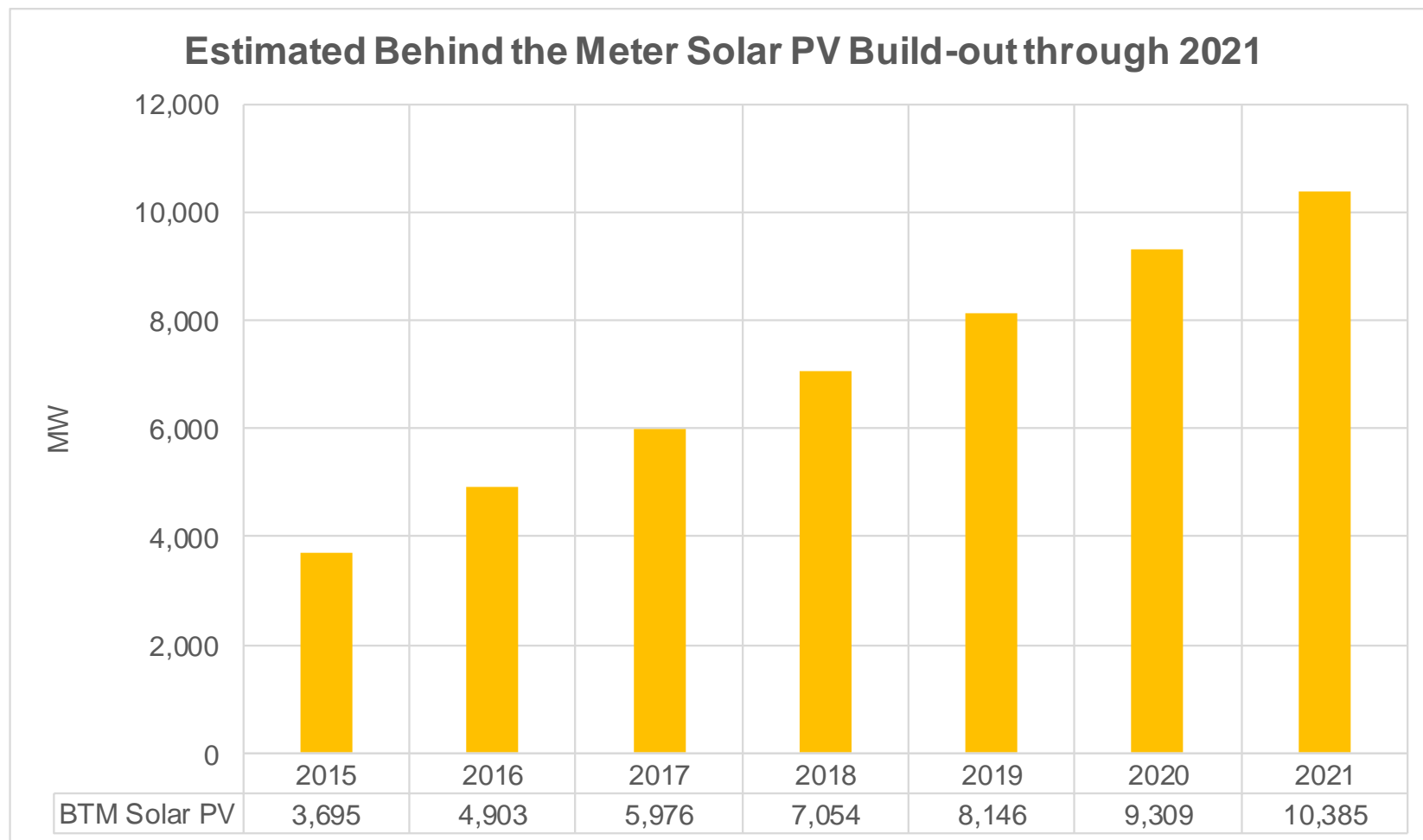
# 5,000 MW of additional transmission-connected renewables by 2020 (predominately Solar PV)



\*All online resources that are not in test mode are included in the 2016 YTD amounts, including those yet to achieve full commercial operation.

\*\*Approximate

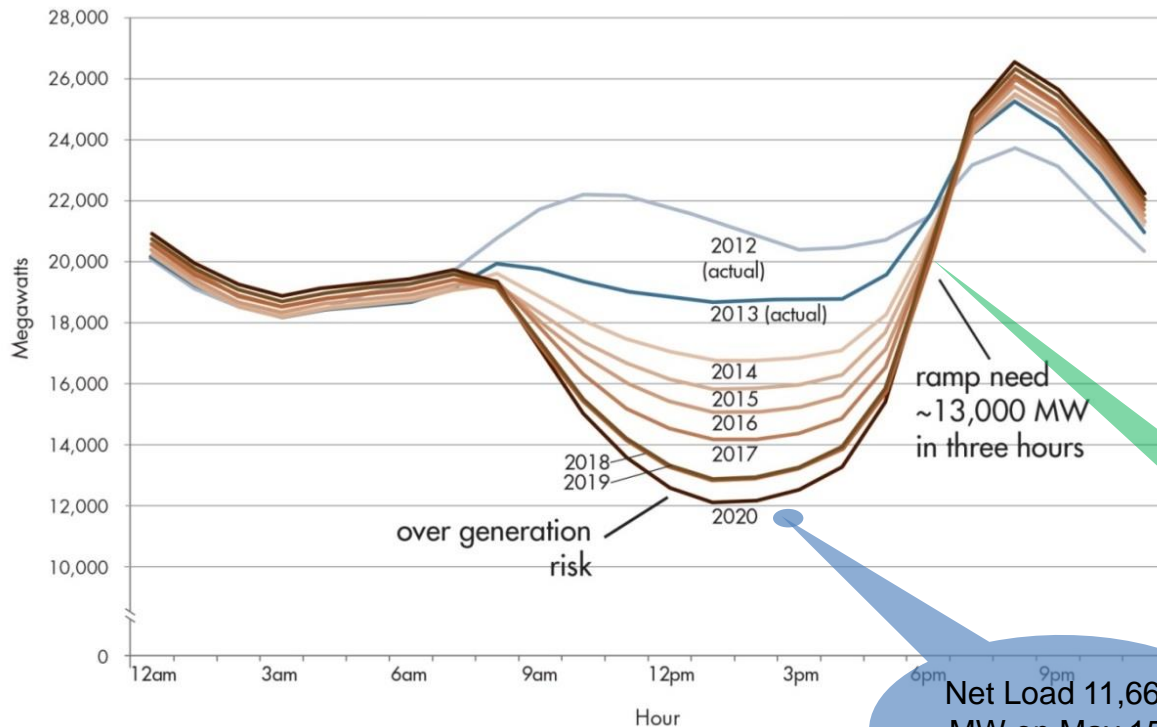
# Behind the meter solar PV build-out through 2021





# Oversupply and ramping: A new challenge as more renewables are integrated into the grid

Typical Spring Day



- ISO has already seen the need to curtail generation
- Oversupply may lead to curtailment because of dispatch limitations on some resources, such as
  - geothermal
  - nuclear
  - small hydro
  - combined heat and power
- Operational requirements include
  - minimum gas necessary to provide ramping
  - necessary ancillary services
  - load following

# TRACKING ROOF TOP SOLAR INFORMATION

# Behind the Meter Solar; Where and How Much?

- In California Publicly Owned Utilities are required, under Senate Bill 1, to report on the progress of their solar incentive program to the California Energy Commission on a yearly basis.
- California Solar Statistics publishes all Investor Owned Utilities solar PV net energy metering interconnection data per CPUC decision (D.)14-11-001, and all IOU data from the California Solar Initiative program per California Senate Bill 1 (SB-1).

Websites:

- <http://www.californiadgstats.ca.gov/>
- [https://www.californiasolarstatistics.ca.gov/data\\_downloads/](https://www.californiasolarstatistics.ca.gov/data_downloads/)
- [http://www.energy.ca.gov/sb1/pou\\_reports/index.html](http://www.energy.ca.gov/sb1/pou_reports/index.html)

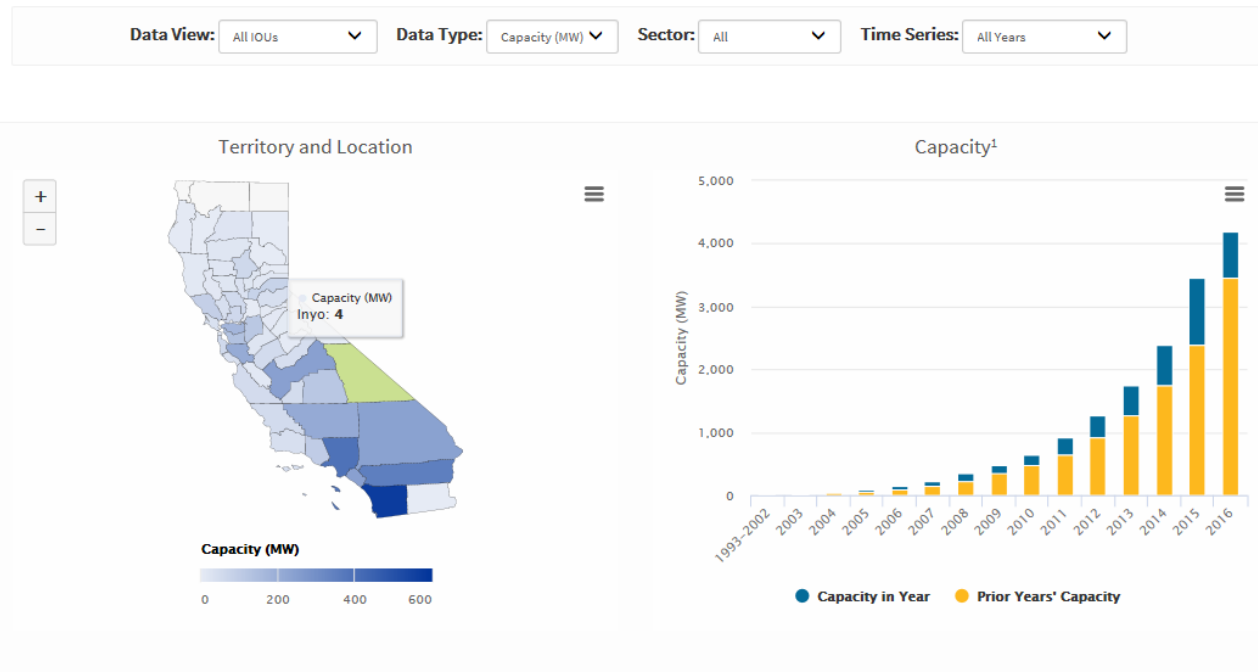


# Current Statistics and Charts: Solar PV

Data Current Through 2016-07-31

## Statistics and Charts: Solar PV

Data Current Through 2016-07-31



- <http://www.californiadgstats.ca.gov/charts/>

# Example: Net Energy Meter Information Report

<http://www.californiadgstats.ca.gov/downloads/>

# MONITORING

# Why Does Cloud Cover Play a Bigger Role in Load Forecasting now?

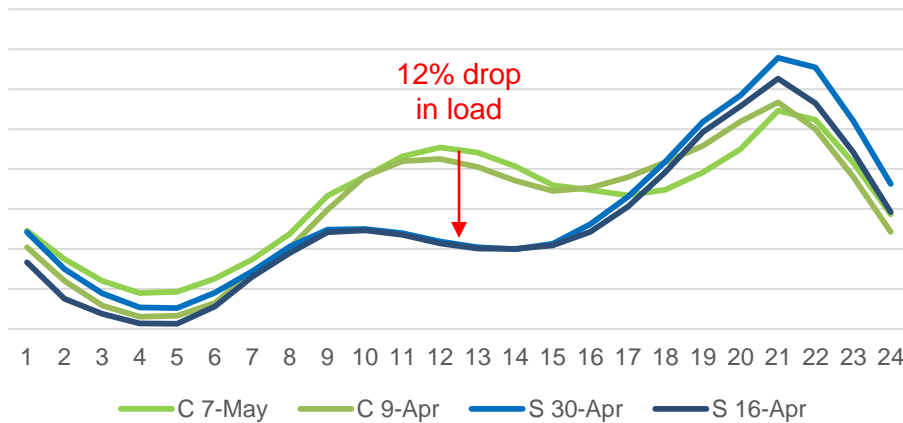
- Before:
  - Cloud cover was fully inter-related to temperatures.
  - Clouds come over = Temperatures Reduce
- Now:
  - Clouds Come Over = Temperatures Reduce = Load Increases
- Note:
  - We are finding in this summer's operations with approximately 5,000 MWs of BTM Solar that there is a temperature that occurs where the effect of the clouds coming over does not raise the forecast but still lowers it like it did prior to BTM Solar.

# Estimated Percentage of Behind the Meter Solar compared to Total Load

	Area 1	Area 2	Area 3	CAISO Total
April-2016	14%	7%	19%	11%
May-2016	11%	8%	22%	11%
June-2016	10%	5%	15%	8%
July-2016	10%	5%	15%	8%
August-2016	12%	6%	16%	9%

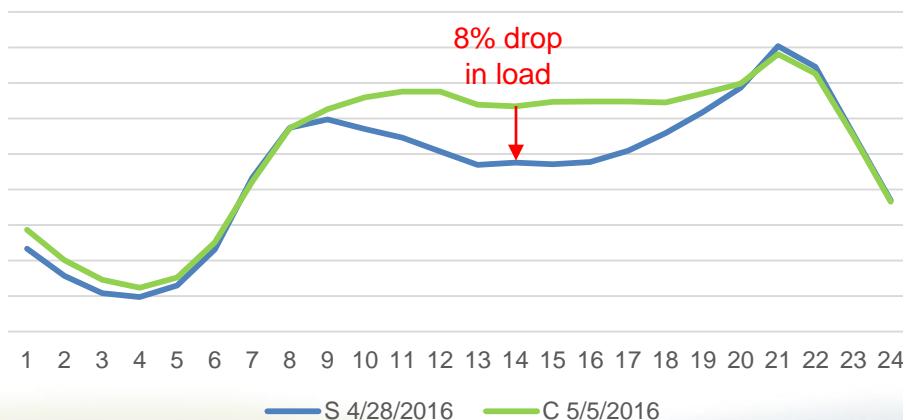
# Area 1 2016

Weekend Effect:  
Sunny Vs. Cloudy



<u>Date</u>	<u>Day of Week</u>	<u>Temp</u>	<u>Sunny or Cloudy?</u>
7-May	Saturday	55/65	Cloudy
9-Apr	Saturday	58/64	Cloudy
30-Apr	Saturday	55/79	Sunny
16-Apr	Saturday	49/80	Sunny

Weekday Effect:  
Sunny vs Cloudy

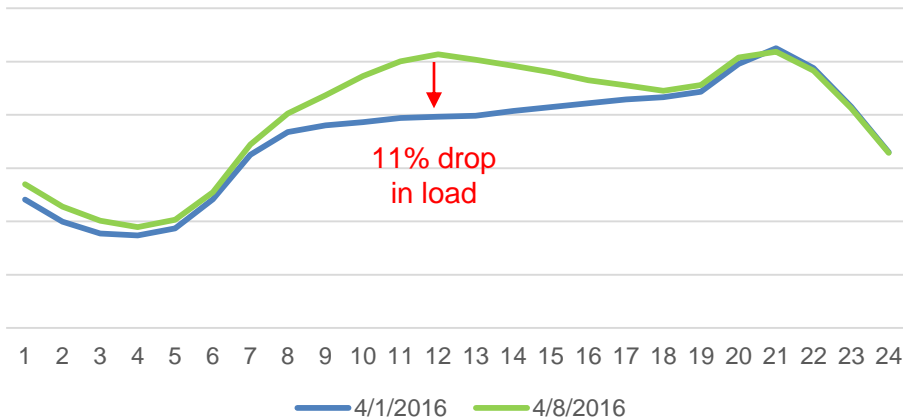


<u>Date</u>	<u>Day of Week</u>	<u>Temp</u>	<u>Sunny or Cloudy?</u>
28-Apr	Thursday	50/73	Sunny
5-May	Thursday	57/68	Cloudy



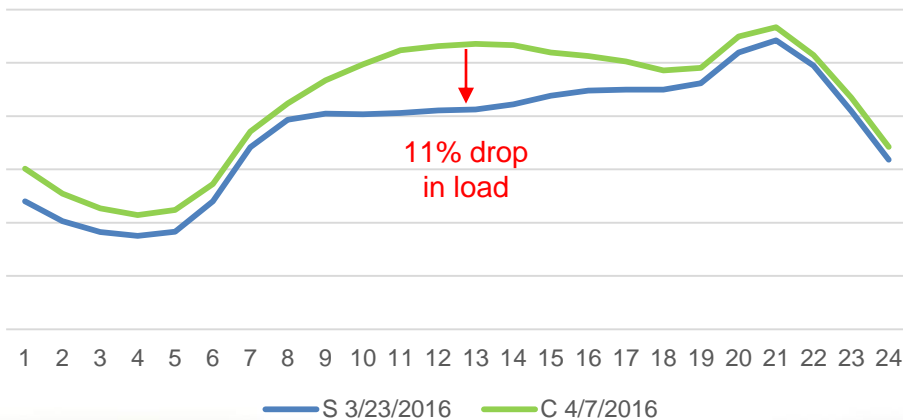
# Area 2 2016

Friday Effect:  
Sunny vs. Cloudy



<u>Date</u>	<u>Day of Week</u>	<u>Temp</u>	<u>Sunny or Cloudy?</u>
1-Apr	Friday	50/77	Sunny
8-Apr	Friday	58/62	Cloudy

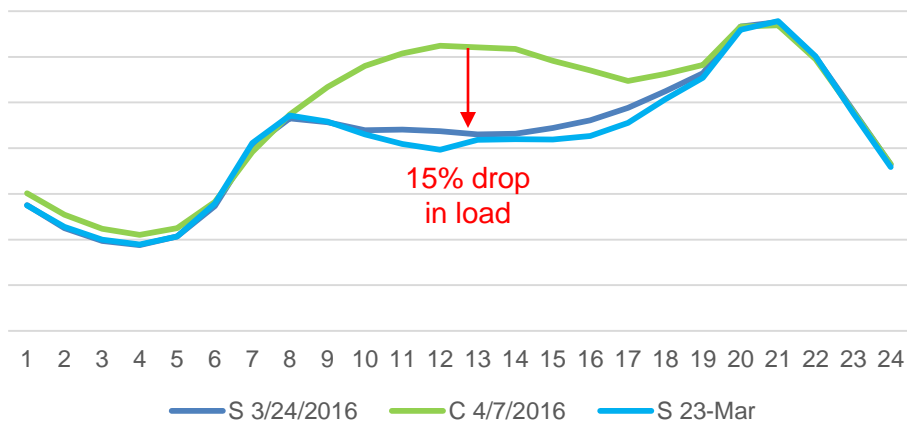
Weekday (M-Th) Effect:  
Sunny vs. Cloudy



<u>Date</u>	<u>Day of Week</u>	<u>Temp</u>	<u>Sunny or Cloudy?</u>
23-Mar	Wednesday	52/75	Sunny
7-Apr	Thursday	63/70	Cloudy

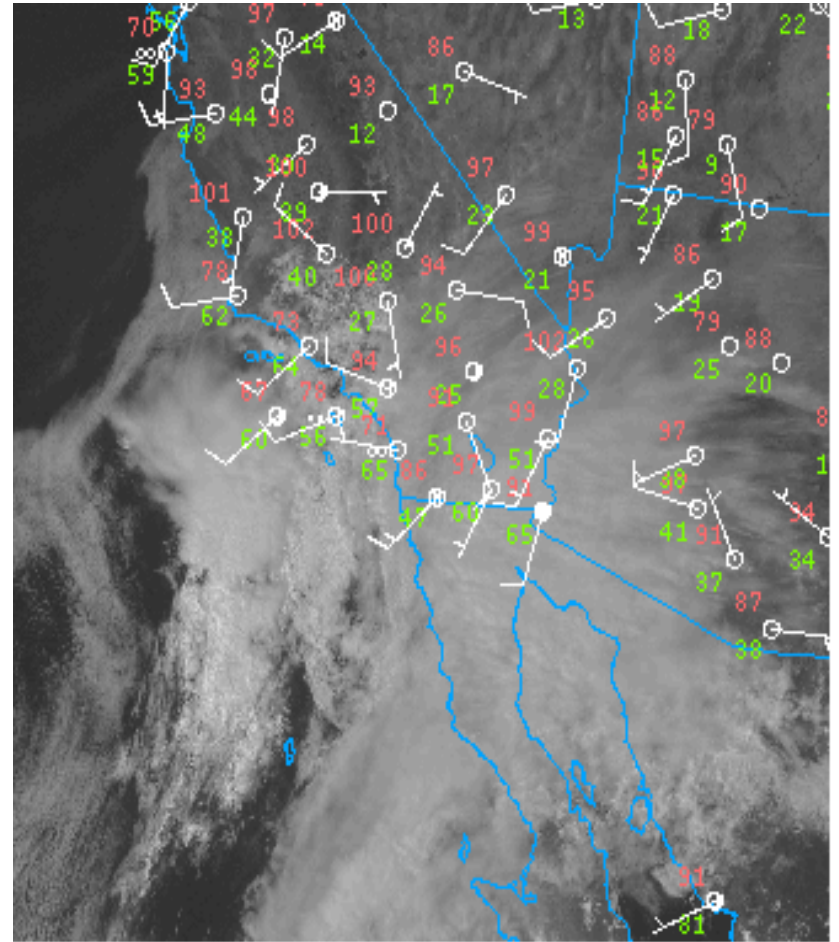
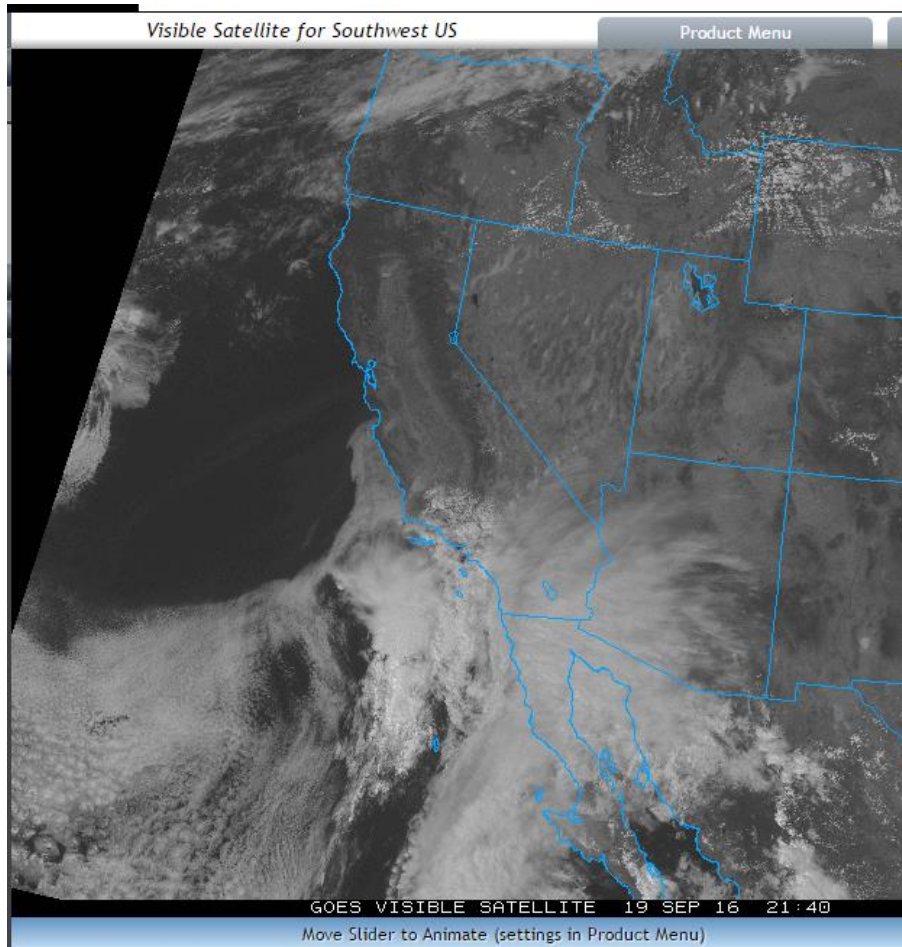
# Area 3 2016

Weekday Effect:  
Sunny vs. Cloudy



<u>Date</u>	<u>Day of Week</u>	<u>Temp</u>	<u>Sunny or Cloudy?</u>
23-Mar	Wednesday	40/73	Sunny
24-Mar	Thursday	42/77	Sunny
7-Apr	Thursday	58/64	Cloudy (but not in AM)

# September 19<sup>th</sup>, 2016 — Real Time Satellite



# September 19<sup>th</sup>, 2016 Temperature

## Burbank, CA

## LA, CA (CQT)

Current time: Mon, 19 Sep 2:54 pm PDT

Most Recent Observation: Mon, 19 Sep 2:40 pm

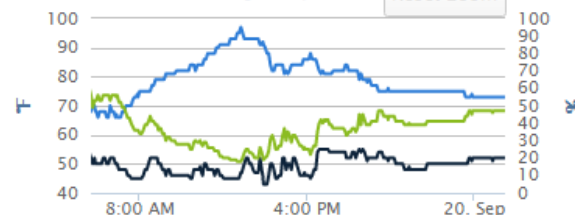
[Explanation of Wx and Clouds columns.](#)

Time	Temp	Dew	Relative	Wind	Wind	Visibility	WX	Clouds	
(PDT)	(f)	(f)	(%)	Direction	Speed	(miles)			
19 Sep 2:40 pm	84	46	27	SE	10	10.00	FEW100 SCT120		
19 Sep 2:35 pm	84	45	25	ESE	8	10.00	CLR		
19 Sep 2:30 pm	84	45	25	SSE	13	10.00	CLR		
19 Sep 2:25 pm	82	48	30	SE	14	10.00	CLR		
19 Sep 2:20 pm	82	50	33	SSE	16	10.00	CLR		
19 Sep 2:15 pm	84	50	31	SSE	18	10.00	CLR		
19 Sep 2:10 pm	88	46	24	SSE	17	10.00	FEW036		
19 Sep 2:05 pm	88	43	21	SSE	16	10.00	FEW037 FEW050		
19 Sep 2:00 pm	90	43	20	S	13	10.00	FEW037 FEW050		
19 Sep 1:55 pm	91	43	19	S	14	10.00	FEW037 FEW050		
19 Sep 1:53 pm	92	46	21	SSE	13	10.00	-RAFEW037 FEW050		
19 Sep 1:50 pm	91	48	23	SSE	14	10.00	-RAFEW037 FEW050		
19 Sep 1:45 pm	91	52	26	SSE	9	10.00	-RAFEW037 SCT050 SCT060		
19 Sep 1:40 pm	93	47	20	SSE	10	10.00	FEW050 FEW060		
19 Sep 1:35 pm	93	47	20	SSE	9	10.00	CLR		
19 Sep 1:30 pm	93	47	20	S	10	10.00	CLR		
19 Sep 1:25 pm	93	48	22	SSE	10	10.00	CLR		
19 Sep 1:20 pm	93	50	23	SE	12	10.00	CLR		
19 Sep 1:15 pm	93	50	23	SE	8	10.00	CLR		
19 Sep 1:10 pm	93	52	25	SSE	8	10.00	CLR		
19 Sep 1:05 pm	93	52	25	SSE	9	10.00	CLR		
19 Sep 1:00 pm	93	50	23	S	8	10.00	CLR		

Temperature, Dew Point & Humidity

Click and drag in the plot area to

Reset zoom



(Click to hide)

— Temperature — Dewpoint — Rel Humidity

Weather Conditions for:

Los Angeles / USC Campus Downtown, CA. **KCQT** (NWS/FAA)

Elev: 179 ft; Latitude: 34.02355; Longitude: -118.29122

Current time: Mon, 19 Sep 3:05 pm PDT

Most Recent Observation: Mon, 19 Sep 2:47 pm

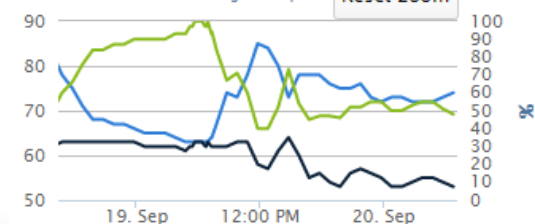
[Explanation of Wx and Clouds columns.](#)

Time	Temp	Dew	Relative	Wind	Wind	Visibility	WX	Clouds	S
(PDT)	(f)	(f)	(%)	Direction	Speed	(miles)			F
19 Sep 2:47 pm	73	64	73	NNE	3	8.00	FEW050 SCT100 BKN120		
19 Sep 1:47 pm	80	61	52	VRBL	5	10.00	-RAFEW039		
19 Sep 12:47 pm	84	57	40	VRBL	3	10.00	CLR		
19 Sep 11:47 am	85	58	40	VRBL	3	10.00	CLR		
19 Sep 10:47 am	78	63	60	VRBL	5	9.00	CLR		
19 Sep 9:47 am	73	63	71	VRBL	3	6.00	HZ CLR		
19 Sep 8:47 am	74	62	67	CALM		6.00	HZ CLR		
19 Sep 7:47 am	67	62	84	CALM		4.00	HZ CLR		
19 Sep 7:20 am	64	62	93	VRBL	5	3.00	BR SCT003		
19 Sep 7:17 am	64	62	93	CALM		2.50	BR SCT003		
19 Sep 6:56 am	63	62	97	NNW	3	2.00	BR OVC002		
19 Sep 6:47 am	63	62	97	CALM		1.25	BR OVC002		
19 Sep 6:42 am	63	62	97	CALM		1.50	BR OVC002		
19 Sep 6:22 am	63	63	100	CALM		2.00	BR OVC002		
19 Sep 6:00 am	63	63	100	CALM		1.75	BR OVC002		
19 Sep 5:47 am	63	63	100	CALM		2.50	BR OVC002		
19 Sep 5:41 am	63	63	100	CALM		2.00	BR OVC002		
19 Sep 5:26 am	63	62	97	CALM		1.50	BR BKN002		
19 Sep 5:20 am	63	62	97	CALM		2.50	BR BKN002		
19 Sep 5:12 am	63	62	97	CALM		4.00	BR FEW002		
19 Sep 4:47 am	63	61	93	CALM		5.00	BR CLR		
19 Sep 3:47 am	64	62	93	CALM		5.00	BR CLR		
19 Sep 2:47 am	65	62	90	CALM		5.00	BR CLR		
19 Sep 1:47 am	65	62	90	CALM		5.00	BR CLR		
19 Sep 12:47 am	65	62	90	CALM		5.00	BR CLR		
18 Sep 11:47 pm	66	63	90	CALM		6.00	BR CLR		
18 Sep 10:47 pm	67	63	87	CALM		6.00	BR CLR		
18 Sep 9:47 pm	67	63	87	CALM		7.00	CLR		

Temperature, Dew Point & Humidity

Click and drag in the plot area to

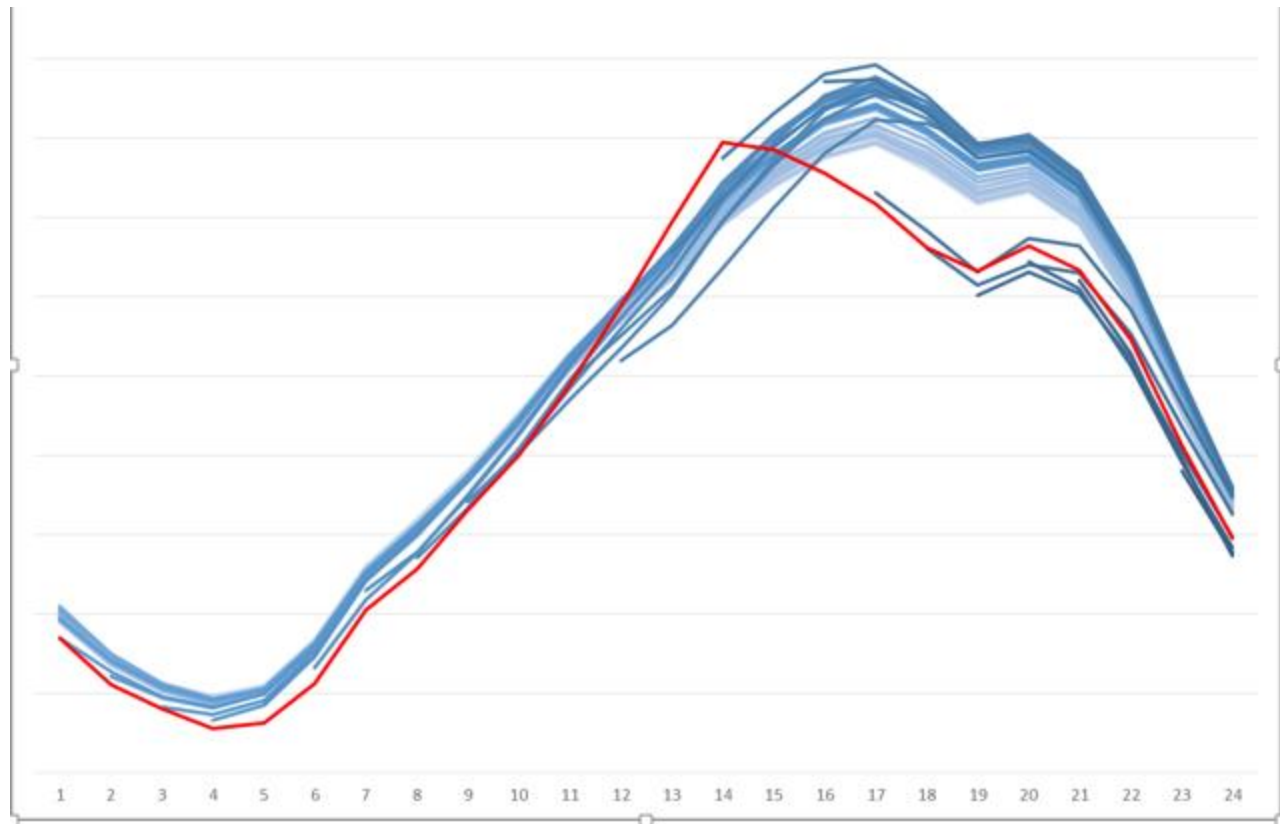
Reset zoom



(Click to hide)

— Temperature — Dewpoint — Rel Humidity

# Load Shape Effect





# WHAT INFORMATION IS NEEDED NEXT?



# Behind the Meter Solar Generation Data Needed

- Standing Data from Solar Site:
  - Orientation of Panels
  - Shading Information
- On-line measurements of well distributed PV Plants
  - This should be physical only PV without load
    - Additional Nice to Have: Historical power measurements of PV plants
    - This does not have to be every distributed PV plant, but for forecasting the load their needs to be enough well placed facilities to upscale the actual generation appropriately.

# Demand Response Data Needed

	Supply Resource DER (SRDER) (Distribution resources, including DR bid into the market)	Load Modifying DER (LMDER) (Distribution resources, including DR, that are outside of our market. This includes behind the meter resources)
Load Forecast	Need for gross and net load forecast with components broken out: Actual Load = Gross Load – SRDER - LMDER.	
Visibility (Load Forecast)	Within 3 days of trade date, provide aggregated 5 minute load impact (Ex Post) for each day. (SC Metered entities provide metered data at T+48B)	On a monthly basis provide the installed capacity broken by technology.  On a daily basis provide next day hourly (Ex Ante) forecasted output for each PNode broken by technology type (i.e. solar, DR, Storage).  Within 3 days of trade date, provide actual 5minute load impact (Ex Post) in aggregate for each day. If estimated numbers are provided, true up due XX days.

For weekends, use WECC trading schedule (i.e. provide data on Friday for Saturday, Sunday and Monday).

# Electric Vehicle (EV)/Battery Data Needed

- On-line measurements of well distributed EV/Battery Information
  - This should be physical only EV/Battery generation/load information
    - Additional Nice to Have: Historical power measurements of EV/Battery Behaviors
    - This does not have to be every distributed Electric Vehicle and Battery, but there needs to be enough well placed facilities to upscale the actual generation/load and behaviors appropriately.

# Other Items for Consideration with Renewable Forecasting

- Challenge of Factoring in Economic Dispatch into Wind/Solar Forecast during real time intervals.
- Effects of Real Time Changing Conditions and the latency effects of getting metered output.
  - Renewable Forecast
  - Distribution System Information
- Place for Probabilistic (uncertainty) Forecasting
  - Regulation Procurement
  - Flexible Ramping Product

A decorative grid pattern of small squares in varying shades of gray, located at the top of the slide.

# THANK YOU

[amotley@caiso.com](mailto:amotley@caiso.com)